Design title: 2025 Micro-g NExT Challenge Challenge-Lunar Operation-Contact Sampling Device

background

NASAworking onArtemisThe mission prepares to head to the Moon's South Pole. existArtemis IIIDuring the mission, astronauts will conduct extravehicular activities (EVA) to collect various lunar geological samples to study multiple scientific fields. One of the scientific research focuses is to investigate the particles that make up the lunar surface regolith (that is, the lunar surface soil), especially to study their particle size, material type, physical distribution and particle orientation, in order to understand the space weathering and history of the moon. To bring back these unique samples, astronauts will need a special contact sampling device to collect and return these samples to Earth. The area sampled must be relatively free ofEVAActivity effects (e.g., dust kicked up by the lander, material kicked up by astronauts walking) to ensure that pristine samples are collected. The device must also be able to contain and store samples for safe return to Earth. If you choose to draw from past missions (e.g. Apollo,OSIRIS-Rex), please apply lessons learned from these tasks and show how your design innovates or improves upon previous designs.

Target

Design a device that would allow astronauts in spacesuits to collect data from the lunar surface“Contact sample”, that is, collecting on the lunar surface1-5mm thick regolith and capture the orientation of surface particles. The device must have a closure method compatible with spacesuit gloves to preserve the sample and safely return it to Earth. The design should also include how scientists will extract samples from the device on Earth. Astronauts will use the device while wearing spacesuits with limited movement, so the ergonomics of the device's operation must be carefully considered in the design. The tool will be located in Houston, TexasNASAJohnson Space Center's Neutral Buoyancy Laboratory (NBL) to evaluate the overall functionality and operational concepts, and at the Lunar Simulation Development Laboratory (SDL) to test its ability to sample and store lunar regolith surface samples.

hypothesis

* we will be inNBLunderwater testing equipment and inSDLLunar regolith simulation materials were used for testing.
* existNBL, we adjust the weight of the test object to be close to the moon's gravity (the Earth's gravity1/6), they will beNBLWalking on the bottom of the pool. The selected team will be responsible for their own testing plan.NBLWill be responsible for facility-related risks (e.g., drowning, barotrauma).
* To simulate a spacesuit, test subjects will wear a surface-supplied diving helmet andEVAGloves. Helmets limit peripheral vision, and gloves reduce finger dexterity.
* NBLThe water temperature of the swimming pool is86°F(about30°C), the depth is40feet (approx.12rice).
* we will be inNBLTest the device in coarse sand at the bottom of the pool.
* existSDL, the team will test their device in a chamber using lunar-simulating materials. The selected team will be responsible for their own testing plan.SDLWill be responsible for risks associated with the facility (e.g. inhalation, handling of simulated materials).
* you will be inSDLTest equipment in a lunar simulation material box.

Hardware provided

* One configured forNBLTesting of lunar contact sampling equipment.
  + we will be inNBLIn evaluating the operational concepts of the device, the test subject will provide feedback on the overall use of the tool.
  + Please bring the assembled device and press it on the moonEVAConfiguration used during.
* A lunar contact sampling device configured for lunar simulation material testing.
  + The device collects and stores1-5The ability to sample lunar regolith surface in millimeters will beSDLTesting using lunar simulation materials.
  + Please bring the part of the equipment used to collect regolith samples. If your design includes ergonomic features, bring a simplified version that only includes the sampling portion.
  + Note: You can choose to use the same set of hardwareNBLand simulated material testing. However,NBLandSDLBetween tests there will be approx.24hour interval. Teams must provide fully dry equipment for simulated material testing, which means you may need to disassemble, dry, or replace certain parts that cannot dry in time.

Require

| **Requirement number** | **Minimum requirements** | **ideal requirements** |
| --- | --- | --- |
| **Functional requirements** | | |
| 1 | You should provide a device capable of usingEVAGloves collected and stored on the lunar surface1-5Millimeters of regolith sample. | We hope the device will also capture the orientation of surface particles. |
| 2 | Equipment should allow the sampling surface to be removed upon return to Earth (wearing nitrile or similar gloves). | We want the sampled surface to be sampled while wearing a spacesuit (usingEVAgloves). |
| 3 | The weight of a tool or tool set should not exceed10Pounds (Earth's gravity). | We want the tool or tool set to weigh no more than5Pounds (Earth's gravity). |
| 4 | The stored equipment should be able to fit a8inchx 8inchx 36inches of space. Note: The expanded device can be of any size as long as one person can operate it. | We hope that the stored equipment can fit into a8inchx 8inchx 16inches of space. Note: The expanded device can be of any size as long as one person can operate it. |
| 5 | For linear drive mechanisms, the required operating force should not exceed20 lbf（89 N). For rotating mechanisms, the required torque should not exceed30 in-lb（3.4 Nm）。 |  |
| 6 | Tools must be manually powered only. |  |
| 7 | Equipment should pass stress analysis and meet or exceed2.0ultimate stress safety factor. You are required to submit a preliminary hand-calculated stress analysis of your proposed design. The stress analysis should include free body diagrams, tracking assumptions and equations. Finite element analysis (FEA) Can be included, but is not required. Normal operation should be assumed when performing stress analysis. The goal of the analysis is to identify the most critical components of the equipment (i.e., the part that fails earliest and has the lowest safety factor). Reports factors of safety based on design, selected materials, and operational input loads. Remember to consider the subcomponents of the mechanism. Note: If your proposal is selected, you will be required to provide additional stress analysis during the spring semester. | We hope that the device will also pass in the moon's gravity (the earth's gravity1/6) down from the ground4ft. Stress analysis for drops in any direction. Note: Although it is not a requirement, consider the effects of equipment falling under Earth's gravity when writing your hazard analysis. |
| 8 | The equipment and any components that separate during operation must be sinkable in water. |  |
| **Material requirements** | | |
| 9 | The device should useNBLApproval of materials in the materials list (see Proposal Guidelines document). These include metals, plastics, lubricants, coatings, foams and adhesives. for absenceNBLApproval of materials in the materials list, teams can apply for exemptions provided a reasonable basis is provided and approved. The proposed hardware design must specify all materials used. ordinaryPLANot available, toughPLAAcceptable. |  |
| 10 | all3DThe fill rate of the printed component is at least75%. This is to ensure3DThe print is strong enough and dense enough to sink in water. |  |
| **security requirements** | | |
| 11 | There should be no sharp edges on the equipment unless required for function. All functional sharp edges must be protected when not in use/Not accessible. | We wanted the device to be able to meet challenging functional requirements without sharp tools. |
| 12 | You should demonstrate the hazards inherent in the device in your proposal and, if selected, in a subsequentMicro-g NExTShown in submitted materials. Please refer to the proposal guidance document for guidance on conducting a hazard analysis. |  |
| 13 | There must be no pinch points on the equipment. Pinch points that cannot be eliminated must beNBLLabeling guideline, which we will provide later. |  |
| 14 | Any uncovered holes or gaps in the equipment, other than tether points, must be smaller than0.5inch(1.27cm) or greater than1.4inch(3.56cm) to avoid getting your fingers stuck. Holes or gaps that cannot be eliminated must be removed in accordance withNBLLabeling guideline, which we will provide later. |  |
| 15 | Hazards that cannot be eliminated (e.g. functional sharp edges) must beNBLLabel guide marked as“don't touch”area, we will provide guidance on that later. |  |
| 16 | The area on the device intended for the user to hold it must beNBLLabeling guideline, which we will provide later. |  |

Other considerations

* Consider what the astronauts will hold onto to stabilize the equipment during operation. The handle should be suitable for use with pressurized spacesuit gloves. NOTE: Smooth, rounded rod handles in spacesuit gloves can cause hand fatigue.

Consider operating while wearing a pressurized spacesuit. Anything that requires fine hand control or puts the astronaut in an unnatural position will be more difficult in a spacesuit.